Study of the morning transition of the atmospheric boundary layer

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1. INTRODUCTION

Objective:

- To analyze the main physical processes dealing with the morning transition of the Atmospheric Boundary Layer (ABL), developing a convective layer from a stable one.

Data:

- Taken from a field campaign during June (CIBA2008) at the Research Centre for the Lower Atmosphere (CIBA). Details related to the campaign and the available instrumentation can be found at poster A335 (this session).

2. METHODOLOGY

Following Angevine *et al.* (2001) and Lapworth (2006), to characterize morning transition, three different times have been evaluated: the **sunrise**, the **crossover** (when sensible heat flux changes from negative to positive) and the **onset** (when convection reaches certain height).

The period considered is from 0300 to 1000 GMT, so that we can study influences previous to sunrise.

Turbulent and stability parameters are studied (see APPENDIX for calculations).

3. RESULTS

According to Bulk Richardson number and the temperature difference between 10m and 1.5m, the different nights can be classified as near-neutral or slightly stable (13-14 to 16-17 June) or very stable (17-18 to 20-21 June). See poster A335.

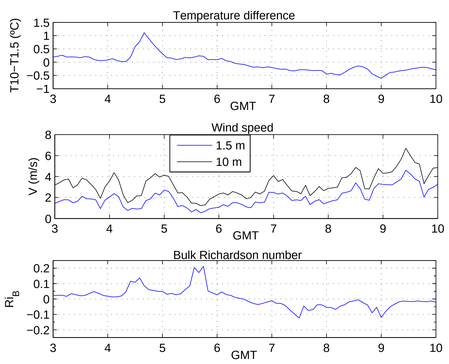

Figure 1. Temperature difference between 10m and 1.5m, wind speed and Bulk Richardson number for 15 June, representative for near-neutral or weakly stable night. Notice the high wind speed values along the night.

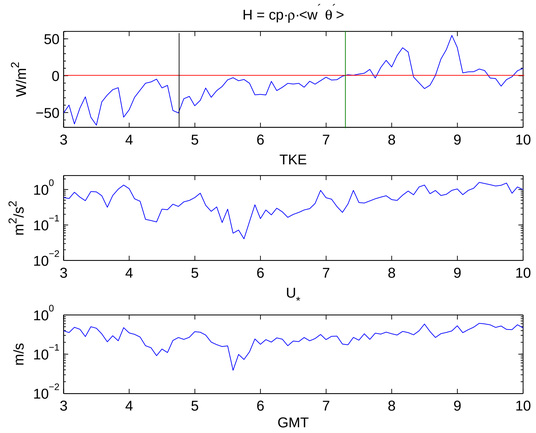

Figure 2. Sensible heat flux, Turbulent Kinetic Energy and friction velocity for 15 June.
Horizontal red line means zero flux. A vertical black line has been drawn at sunrise time. Crossover is represented by a vertical green line.

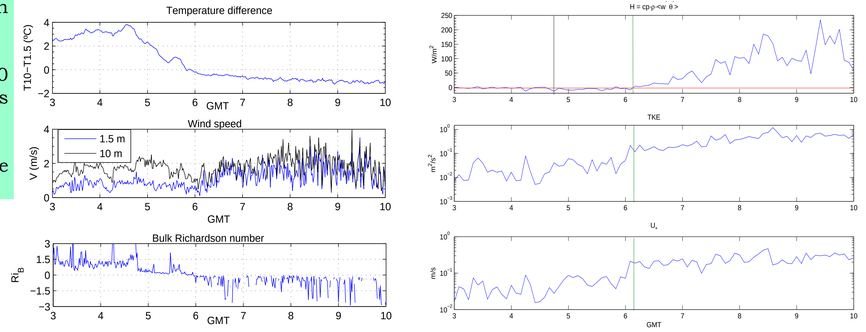

Figure 3. Same as figures 1 and 2 for day 19 June, representative for very stable night.

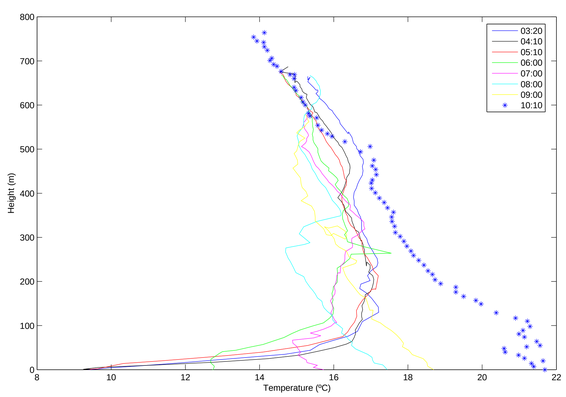

Figure 4. Temperature soundings at different times for 19 June.
Convective influence from the ground is noticed at 0600GMT (nearly crossover time) and reaches about 100 meters one hour later.

4. CASE STUDY

20 June morning transition is studied in detail, making also a wavelet analysis to find both spectral and temporal location of coherent structures [Nappo, 2002].

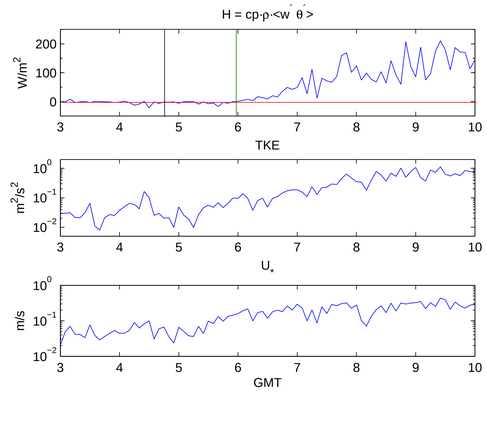

Figure 5. Sensible heat flux, turbulent kinetic energy and friction velocity for 20 June.
Horizontal and vertical lines mean the same as in figure 2.

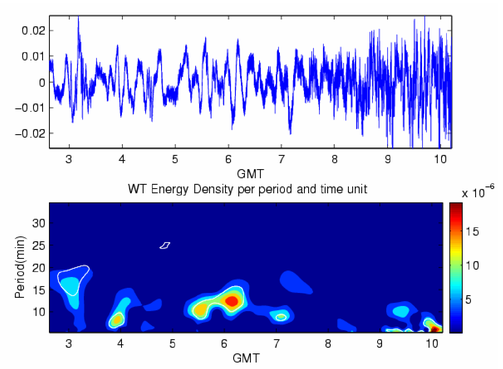

Figure 6. Pressure perturbations and wavelet map at surface from 0300GMT to 1000GMT.

It is found a coherent structure around 0600 GMT (crossover time), with a period of about 13 minutes. Wave parameters obtained from wavelet analysis [Terradellas *et al.*, 2001] give a phase speed much larger than the typical waves detected during stable nights at CIBA, which are usually Kelvin-Helmholtz waves; in this case it could have a different origin: the **initial convection of the morning**.

5. CONCLUSIONS

- In morning transitions preceded by strongly stable nights, the time between sunrise and crossover is around one hour and a quarter.

- The incipient convection at the initial hours of the morning generates some perturbations near the ground which can be seen as coherent structures.

- Further research is required to establish its influence on the development of the convective boundary layer.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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Terradellas, E., Morales, G., Cuxart, J., and Yagüe, C. (2001): Wavelet methods: application to the study of the stable atmospheric boundary layer under non stationary conditions, *Dyn. Atmos. Oceans*, **34,** 225–244.

APPENDIX: Stability and Turbulent parameters

Temperature difference

$$\Delta T = T_{10\,m} - T_{1.5\,m}$$

Friction velocity

$$U_* = \sqrt[4]{(\overline{u'w'})^2 + (\overline{v'w'})^2}$$

Turbulent kinetic energy

$$TKE = \frac{1}{2}(\overline{u'^2} + \overline{v'^2} + \overline{w'^2})$$

Bulk Richardson number

$$Ri_{B\,(z_1 - z_2)} = \frac{g}{T_o} \cdot \sqrt{z_1 \cdot z_2} \cdot \left(\ln \frac{z_2}{z_1} \right) \frac{\Delta \theta}{(\Delta U)^2}$$